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A METHOD FOR DETECTING TRACKING SHORT

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A METHOD FOR DETECTING TRACKING SHORT

TECHNICAL FIELD

The present invention relates to a method for detecting tracking short in electric circuit. If once a carbonized conductive passage is formed in the isolator posed between two points of an electric circuit, current begins to flow between them through the above passage. Then, the carbide included in the passage becomes red-hot, and it causes the carbonization of the isolator around the passage. As this is repeated, the amount of current flowing between two points in the electric circuit becomes increasing, and finally it causes fire or burning. Such a phenomenon is so called 'tracking short'. Tracking short is likely to occur especially in the outlets or plugs that haven't be used for a long time, and once occurring, it is tend to be developed to fire.

BACKGROUND ARTS

As a first conventional method for detecting the occurrence of short in an electric circuit, it is known that detecting a current value in the electric circuit using a current transformer, converting the current value to a voltage value by a current-voltage converter, A/D converting the voltage value by an A/D converter, and judging whether the short has occurred or not on the base of the A/D converted value. In this method, the judgement whether the short has occurred or not is performed by summing up the A/D converted values only for the predetermined period by a integrate circuit, comparing the sum with the predetermined reference value, and outputting the signal indicating the occurrence of short when the sum exceeds the reference value.

As a second conventional method for detecting the occurrence of short in an electric circuit, it is known that detecting a current value at every unit time and judging whether the short has occurred or not on the base of the variation of the absolute value of the current value. In this method, for example, when the second current value is smaller than the first current value and the third current value is

bigger than the second current value, the signal indicating the occurrence of short is outputted.

However, according to the first conventional method, as the current values only for the predetermined period are summed up, it is needed to set the reference value smaller than the summed value to detect the relatively small short current such as in case of tracking short. In case of general short of two wires getting in touch with each other, the short current flowing between two wires is over several hundreds Ampare. In the contrary, in case of tracking short, the short current is several Ampare ~ several scores Ampare. Therefore, in this conventional method, the reference value has to be below several Ampare ~ several scores Ampare to detect the tracking short. However, occasionally several Ampare ~ several scores Ampare of sudden over-current could flow in the electric appliance like incandescent lamps, and it is difficult to distinguish such a sudden over-current from the tracking short current. For example, in the incandescent lamp of 20 Ampare rated current, the sudden over-current could be 200 Ampare in maximum.

Further, according to the second conventional method, in case of using several household electric appliance simultaneously, the variation of current value of each appliance is mixed up, and occasionally it could show the same amount of variation that appears in tracking short. Therefore, it is still difficult to detect the tracking short without error by distinguishing the current caused by the use of several household electric appliance from the tracking short current.

As discribed above, according to the conventional methods, it is very difficult to detect the tracking short without error. It is because the current caused by tracking short is almost same with the current caused by the normal use of electric appliance.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a method for detecting tracking short without error by distinguishing the tracking short current from the current caused by the normal use of electric appliance.

The inventors performed the followed comparison test. The test is for comparing frequency distribution of current variation caused by tracking short in the plug with that of current variation caused by the normal use of several kinds of household electric appliance.

The above predetermined period is about 0.2 sec, the above unit time is obtained by dividing the predetermined period by 7 parts, and the above current value obtained at every unit time is the absolute value of the peak value of current in the unit time.

Whenever obtaining the current value, we compared it with the current value obtained at previous unit time and wrote down the difference between them as the variation for each unit time. By repetition, we got frequency distribution of variation, and then compared the case of tracking short with the case of the normal use of household electric appliance.

We made tracking short intentionally by carbonizing the insulator between tracking electrodes in advance and supplying a AC(100V) power to there. Then, we observed the waveform of current right after the occurrence of tracking short.

In addition, we observed the waveform of the current when the power was turned on with the rated voltage of several kinds of household electric appliance.

As a result, we got Fig.2 and Fig.6 that show the frequency distribution of current variation. In Fig.2 and Fig.6, the vertical axis indicates the variation(Ampare) at each unit time, and the horizontal axis indicates the rate(%) of the summed value of frequencies in each variation range over the total sum of frequencies in the predetermined period.

Fig.2 shows the frequency distribution of current variation in case of the occurrence of tracking short, and Fig.6 shows the frequency distribution of current variation for the appliance showing the biggest variation among the several kinds of household electric appliance.

In comparison of Fig.2 with Fig.6, Fig.2 shows that the variation is mostly concentrated in the range of 0～4 Ampare, and Fig.6 shows that although it generally spreads broadly, the variation in the range of 5～30 Ampare is a little more than that in other ranges.

The present invention is achieved on the base of the result of the above test for the purpose of detecting tracking short. And, it takes advantage of the fact that the frequency distribution of the current variation in tracking short shows a characteristic feature.

The inventors of the present invention achieved the following invention on the base of the above test.

According to claim 1, the present invention is provided with a method for detecting tracking short with the current value on the electric circuit comprising the steps of measuring the current value during the predetermined period to obtain the frequency distribution of the absolute value of current variation, comparing the rate of the frequencies in a predetermined range over the total frequency with the reference value, and judging tracking short to have occurred when said rate is

above the reference value.

The invention according to claim 1 is applied to detect the occurrence of tracking short, and makes it possible to detect it without error by the new method taking advantage of the frequency distribution of current variation as a judgement condition.

According to claim 2, the present invention is provided with a method for detecting tracking short with the current value on an electric circuit comprising the steps of measuring the absolute current value at each unit time to obtain the current waveform which is used for judgement wherein the uint time is what is obtained by dividing the predetermined period into several, calculating the variation of the current value at each unit time by getting the difference between the absolute current value at each unit time and that at right previous or next unit time, and judging tracking short to have occurred when the frequency in the predetermined variation range for the predetermined period satisfies the pre-set reference.

The invention according to claim 2 provides more specific configuration of the invention according to claim 1.

According to claim 3, the present invention is provided with a method for detecting tracking short according to claim 2 wherein there exist a plurality of variation ranges, and said reference of frequency is set for the each of said plurality of ranges, wherein the said judgement step is configured to judge the occurrence of tracking short when each frequency in all the ranges satisfies the corresponding reference.

The invention according to claim 3 is another specific configuration of the invention according to claim 2 for more accurate judgement with more judgement conditions.

According to claim 4, the present invention is provided with a method for detecting tracking short according to claim 2 or 3 wherein said judgement is performed at every unit time during the predetermined period.

The invention according to claim 4 makes it possible to output a result as soon as the tracking short occurs by dividing the predetermined period into several unit times, performing the judgment step at every unit time, and outputting the result at every unit time. Further, it becomes possible to use the data memory means of a relatively small capacity by erasing an oldest datum of past predetermined period at every unit time.

According to claim 5, the present invention is provided with a method for detecting tracking short according to claim 2, 3 or 4, further comprising the steps of dividing the unit time into several, obtaining the absolute value of the peak value of the current in every said divided time, calculating the difference between each said obtained value and previous or next value of it, and initializing and restarting said judgement step when the absolute value of the difference is below the predetermined reference value.

The invention according to claim 5 is providing more errorless method for detecting tracking short. More specifically, it is possible to protects the error much better by further dividing the unit time into several parts and giving a corresponding judgement condition to each part, because it is often that the current variation exceeds the reference value only for pretty short time in case of tracking short.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the configuration of the circuit according to the present invention.

Fig. 2 is a graph illustrating the exemplary frequency distribution of current variation in case the tracking short occurs.

Fig. 3 is for explanation of the detecting method by the present invention according to claim 2.

Fig. 4 is for explanation of the detecting method by the present invention according to claim 4.

Fig. 5 is for explanation of the detecting method by the present invention according to claim 5.

Fig. 6 is a graph illustrating the exemplary frequency distribution of current variation in case of the household electric appliance.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A method for detecting tracking short according to the present invention is characterized in detecting current in an electric circuit and judging the occurrence of tracking short on the base of the variation of the detected current for the predetermined time.

This invention will be described in further detail by way of example with reference to the accompanying drawings.

Referring to Fig. 1, there is shown a block diagram showing the configuration of the circuit of one preferred embodiment in case of applying the detecting method of the invention to a circuit breaker. As shown in Fig. 1, the circuit breaker of the embodiment is including a current transformer 1, a current-voltage convertor 2, a rectifier circuit 3 and a judgement circuit 11.

Said current transformer 1 detects current flowing in an electric circuit 10 and outputs AC current.

Said current-voltage convertor 2 converts the AC current outputted from said current transformer 1 into the AC voltage, particularly through a resistor.

Said rectifier circuit 2 rectifies the output voltage from said current-voltage convertor 2 using diodes etc. and outputs the absolute value of it. By using the absolute value, when A/D convertor digitalizing the voltage, the higher resolution can be obtained than that in case not using the absolute value.

Said judgement circuit 11 is configured to always observe the output voltage from said rectifier circuit 3, judge whether the current is corresponding to tracking short or not, and, in case tracking short occurs, output a cut-off command signal to the cut-off circuit so that a cut-off coil opens the contact of the circuit breaker.

Said judgement circuit 11 is comprising a microcomputer including the A/D convertor 4, a ALU 12, a register circuit 13, and a judgement output circuit 6.

Said A/D convertor 4 digitalizes the output voltage from said rectifier circuit 3 by dividing the voltage into the predetermined time width(sampling time) of the several milli second or below. For example, the sampling time can be about 0.25 ms.

For example, when the maximum input voltage of the A/D convertor 4 is 5V, and the resolution of the digitalization is 8bit, the output of the A/D convertor 4 is 0 for 0V of input voltage, 127 for 2.5V, and 255 for 5V. Here, if adjusting the current-voltage convertor 2 so that the current of 1bit is corresponding to 1A when A/D converting, it is possible to observe the current waveform of 0A ~ +255A with said A/D convertor 4. Further, as the means for digitalization, said ALU 12 equipped with said A/D convertor 4 inside can be used.

Said ALU 12 processes the current variation numerically on the base of A/D converted value by said A/D convertor 4, and outputs the current variation data to said register circuit 13. Further, it reads out the variation data stored in said register circuit 13, performs the judgement the occurrence of tracking short according to built-in program, and outputs the result signal to said judgement output circuit 6 in case the tracking short occurs.

Said register circuit 13 is always retaining a plurality of current variations for the recent predetermined period in time order by erasing the oldest current variation simultaneously writing in the latest current variation whenever the new current variation is tranmitted from said ALU 12. It is preferred that the number of the current variation always retained in said register circuit 13 is for example more than 7 for the accuracy of judgement. Also, It can be decided according to the capacity of the memory in the microprocessor and the length of judgement time.

Said judgement output circuit 6 receives the judgement signal from said ALU 12 and ouputs a signal to said cut-off circuit.

Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 1.

Said ALU 12 extracts the peak value of current at every half-wavelength from the data of each sampling time transmitted from said A/D convertor 4, compares it with the right previous peak value, and transmits the difference of them to said register circuit 13 as a current variation. Then, Said register circuit 13 stores the current variation data of the predetermined period, and, when receiving the new data from said ALU 12, erases the oldest data with writing in the latest data. Herein, the predetermined period is preferred to be about 0.2 sec.

Said ALU 12 transmits the latest data to said register circuit 13 and takes the current variation data from said register circuit 13. And then, it calculates the frequency distribution of the variation such as shown in Fig. 2 with the variation of the each data, and calculates the sum of frequencies in the predetermined variation range and the total frequency. After that, it calculates the rate of the sum of frequencies in the predetermined variation range over the total frequency, and judges whether the rate is above the judgement reference or not.

Referring to Fig. 6, there is shown a exemplary frequency distribution of the current variation in case of using household electric appliance. It is shown that the frequency of variation is concentrated in the range of 0 ~ 4 A. On the contrary, Fig. 2 is a exemplary frequency distribution of the current variation in case of tracking short, and it is shown that the most frequency of variation is existed in the range of 5 ~ 30A. Therefore, by way of calculating what percentage the frequencies in the variation range of 5 ~ 30A occupies about the total frequency and judging whether it exceeds the judgement reference or not, it is possible to judge exactly whether the flowing current is caused by the use of household electric appliance or by tracking short even though the magnitude of the flowing currents in both cases are almost same.

Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 2. Herein, the judgement by said ALU 12 is performed on the base of the data for the predetermined period, and the

predetermined period is about 0.2 sec.

Fig. 3 is for the explanation of unit time A(i), detected current value IPA(i) at each unit time, current variation ΔIPA(i), and predetermined period according to claim 2. The predetermined period is divided into a plurality of unit times A(i)(here, i=1~n, n is a positive number). IPA(i) is a current value that said ALU 12 extracts in the unit time A(i) from the data transferred from said A/D convertor 4 in Fig. 1 at every sampling time. Although, in this embodiment, said IPA(i) is a peak value in the unit time A(i), it can be a average value in the unit time A(i). Δ IPA(i) is a variation corresponding to the difference of a current value in the unit time and a current value in the right previous unit time. Namely, it can be expressed as the difference of IPA(i) and IPA(i-1).

Referring to Fig. 3, said register circuit 13 is retaining n data of ΔIPA(1)~Δ IPA(n) and a datum of IPA(n). The initial status of said data is set zero.

Then, said A/D convertor 4 transmits the data at each sampling time to said ALU 12. Said ALU 12 extracts the peak value IPA(n+1) of current in the unit time A(n+1) with simultaneously reading out the previous peak value IPA(n) from said register circuit 13.

Then, said ALU 12 calculates the ΔIPA(n+1) by the following equation.

ΔIPA(n+1)=IPA(n+1)-ΔIPA(n)

And then, it transmits the new value of ΔIPA(n+1) and IPA(n+1) back to said register circuit 13, wherein if the ΔIPA(n+1) is negative, making it positive before transmission.

Said register circuit 13 is already retaining n data of ΔIPA(1)~ΔIPA(n) and a datum of IPA(n) as shown in Fig. 4 even before receiving the ΔIPA(n+1) from said ALU 12. Therefore, if receiving the new data of ΔIPA(n+1) and IPA(n+1) from said ALU 12, said register circuit 13 erases the oldest data of ΔIPA(1) and IPA(n) and shifts the value of ΔIPA(2) to ΔIPA(1), ΔIPA(3) to ΔIPA(2)⋯ΔIPA(n+1) to

ΔIPA(n) and IPA(n+1) to IPA(n). At the same time, said ALU 12 reads out the renewed n data of ΔIPA(1)～ΔIPA(n) from said register circuit 13, calculates the sum of the number of data in the range of 5～30A of ΔIPA(i) as a frequency, and outputs the judgement signal indicating the occurrence of tracking short to said judgement output circuit in case the frequency is more than n×0.7.

According to above method of claim 2, it makes possible to judge whether the tracking short occurs or not with the much more simple judgement procedure of just comparing the sum of data in the predtermined range with the reference than the method of claim 1 wherein the ALU 12 makes the frequency distribution and calculates the rate.

According to claim 3, in addition to judgement condition about the number of data of which current variation is in the range of 5～30A, having another condition that the number of data of which current variation is in the range of 11～30A is above n×0.4, the judgement that the tracking short has occurred is issued when the both of conditions are satisfied. This make it possible to increase the accuracy of distinguishment between the current due to tracking short and the current due to the use of household electric appliance.

Fig. 5 is for the explanation of judgement procedure according to claim 5. Therein, the unit time A(i) is further divided into m parts Ta(i,1)～Ta(i,m)(m is a positive number). In this embodiment, Ta(i,j) is a corresponding time to the half-wavelength of the frequency of commercial AC power. As a cycle could be 50Hz or 60Hz according to the area, it is set a middle value, that is, about 9ms.

In Fig. 5, IPT(i,j) is the peak value of the current in a divided time Ta(i,j), and ΔIPT(i,j) is the value obtained by subtracting IPT(i,j-1) from IPT(i,j). Said ALU 12 receiving the data from said A/D converter 4 at every sampling time, extracts the peak value of current IPT(i,j) in each divided time and calculates the ΔIPT(i,j) with the previous peak value IPT(i,j-1) by the following equation.

$\Delta IPT(i,j)=IPT(i,j)-IPT(i,j-1)$

Herein, if the $\Delta IPA(i,j)$ is negative, it is converted to positive.

At the same time, said ALU 12 calculates $\Delta IPT(i,j)$ for each divided time $Ta(i,1) \sim Ta(i,m)$. And then, if the $\Delta IPT(i,j)$ is above the predetermined value(it is set 5A in this embodiment), said ALU 12 proceeds to calculate the next $\Delta IPT(i,j)$. If the next $\Delta IPT(i,j)$ does not satisfy the predetermined value, said ALU 12 initializes all the procedure including the procedure of claim 2 and 3 and begins the judgement procedure again from the first stage.

More specifically, if all the values of $\Delta IPT(i,2) \sim \Delta IPT(i,m)$ in the unit time A(i) are above the predetermined value, said ALU 12 continues the procedure of extracting the peak value of the current $\Delta IPT(i)$ in the unit time A(i), obtaining the current variation $\Delta IPT(i)$ by calculating the difference between $\Delta IPT(i)$ and IPA(i-1), and transmitting it to said register circuit 13. However, otherwise, all the data in the register circuit 13 are initialized. Therefore, for said ALU 12 to judge that the flowing current is caused by tracking short and output a signal to the judgement output circuit 6 in Fig. 6, it is needed to satisfy two conditions at the same time. One is that all the values of $\Delta IPT(i,2) \sim \Delta IPT(i,m)$ illustrated in Fig. 5 are above the predetermined value and the procedure is being continued, and the other is that the current variation in each unit time $A(1) \sim A(n)$ satisfies the condition in claim 2 or 3. In tracking short, most of above $\Delta IPT(i,j)$ are sustained above the predetermined value, therefore, according to claim 5, it is possible to judge more exactly whether the current flowing on a circuit is caused by tracking short or not without malfunction.

As described above, the present invention is described through the embodiments applying to the circuit breaker configured to breaks the circuit when detecting the occurrence of tracking short. But, the present invention is not restricted to the circuit breaker, and it can be applied to outlets or it can be configured to alarm using a output signal of the judgement circuit 11.

Industrial applicability

As above, according to the present invention, by taking advantage of the current variation in judgement of the occurrence of tracking short, it becomes possible to judge exactly whether tracking shot has occurred or not in short time, even though the currents caused by tracking short and by normal usage of electric device are almost same. In addition, it becomes possible to discriminate tracking short without error taking advantage of the characteristic current variation even though there occurs a load current or sudden overcurrent, or a plurality of household electric appliance are in use. Therefore, if the present invention is applied to the device connected to the power line for home or factory, it can be prevented for tracking short to cause fire.